CHAPTER 42

Miscellaneous Heart Sounds

KEY TEACHING POINTS

- Miscellaneous heart sounds can be classified by their timing: early systolic sounds (ejection sounds), mid-to-late systolic sounds (click of mitral valve prolapse), and early diastolic sounds (opening snap of mitral stenosis, pericardial knock of constrictive pericarditis, and tumor plop of atrial myxoma).
- If a patient with a rigid prosthetic heart valve presents with chest pain, dyspnea, or syncope, the clinician should carefully document the prosthetic heart sounds. In caged-ball valves the opening sounds should be loudest (early systolic for aortic position; early diastolic for mitral position). In tilting-disc valves the closing sounds should be loudest (S_2 for aortic position; S_1 for mitral position). Failure to elicit these findings may indicate valve thrombosis.

In addition to the first, second, third, and fourth heart sounds, several other discrete, short sounds may occur (Fig. 42.1). These sounds include early systolic sounds (e.g., the aortic or pulmonary ejection sound), midsystolic or late systolic sounds (e.g., systolic click of mitral valve prolapse), early diastolic sounds (e.g., opening snap of mitral stenosis, pericardial knock of constrictive pericarditis, and tumor plop of atrial myxoma), and prosthetic valve sounds. All are high-frequency sounds best heard with the diaphragm of the stethoscope.

EJECTION SOUNDS

I. THE FINDING AND PATHOGENESIS

The ejection sound is the most common early systolic sound. It results from abnormal sudden halting of the semilunar cusps as they open during early systole[2,3] Patients with aortic ejection sounds typically have aortic stenosis, bicuspid aortic valves, or a dilated aortic root.[2,3] Those with pulmonary ejection sounds have pulmonary stenosis, pulmonary hypertension, or a dilated pulmonary trunk.[3,4]

Aortic and pulmonary ejection sounds are distinguished by their location, associated murmurs, and how they vary during respiration. An aortic ejection sound is a loud high-frequency sound (often louder than S_1) best heard at the apex, although commonly also audible at the upper right sternal border.[5] It does not vary with respiration. Pulmonary ejection sounds are confined to the sternal edge at the second or third intercostal space; they often diminish in intensity during inspiration. Ejection sounds associated with aortic or pulmonic stenosis occur immediately before the onset of the systolic murmur.[5,6]

Chapter 41 describes how to distinguish ejection sounds from other double sounds around S_1, including the combination of S_4-S_1 and the split S_1.

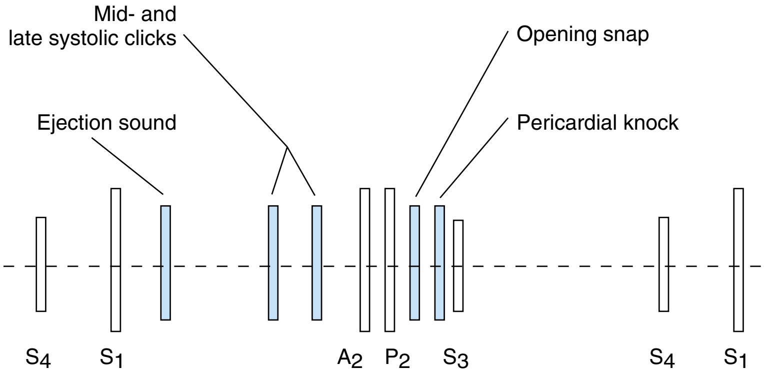

FIG. 42.1 MISCELLANEOUS HEART SOUNDS. The figure shows the timing of the miscellaneous systolic sounds (ejection sounds and mid-to-late systolic clicks) and diastolic sounds (opening snap and pericardial knock), in relation to the principal heart sounds (first, second, third, and fourth heart sounds). The tumor plop of atrial myxoma, not depicted in the figure, has variable timing, ranging from 80 ms after A_2 (i.e., timing of the opening snap) to 150 ms after A_2 (i.e., timing of the third heart sound).[1]

II. CLINICAL SIGNIFICANCE

The primary importance of these sounds is their etiologic associations. In patients with aortic stenosis the ejection sound implies that the stenosis is at the valvular level and that there is some mobility to the valve. Elderly patients with calcific aortic stenosis usually do not have ejection sounds because the calcific degeneration makes the valve leaflets inflexible. In contrast, children with noncalcific aortic stenosis usually have the ejection sound. In one consecutive series of 118 patients with aortic stenosis, the ejection sound was audible in 100% of patients with noncalcific valvular stenosis, in 32% with calcific valvular stenosis, and in none with subvalvular or supravalvular stenosis.[5]

MID-TO-LATE SYSTOLIC CLICKS

I. THE FINDING AND PATHOGENESIS

Mid-to-late systolic clicks occur in patients with mitral valve prolapse. These sounds, which are sometimes multiple, are caused by sudden deceleration of the billowing mitral leaflet as it prolapses backward into the left atrium during systole.[7] The click is loudest at the apex or left lower sternal border and is frequently associated with a late systolic murmur.[8]

The hallmark of the click of mitral valve prolapse (and also of the associated murmur) is that its timing shifts during maneuvers that change venous return. For example, the straining phase of the Valsalva maneuver or the squat-to-stand maneuver, both of which decrease venous return, cause the mitral leaflets to prolapse earlier in systole, thus shifting the click (and murmur) closer to S_1 (see Fig. 46.1 in Chapter 46).[8,9]

Clicks have been heard by clinicians for more than a century, although they were ascribed to pleuropericardial adhesions or other extracardiac causes[10] until the

1960s, when Barlow demonstrated the sound coincided with systolic prolapse of the posterior mitral leaflet.[11]

II. CLINICAL SIGNIFICANCE

The presence of the characteristic click or murmur alone is sufficient grounds for the diagnosis of mitral valve prolapse.[12,13] Chapter 46 discusses these findings further.

OPENING SNAP

I. THE FINDING AND PATHOGENESIS

The opening snap is an early diastolic sound heard in patients with mitral stenosis.* The sound occurs because the stenotic mitral leaflets (although fused, they are mobile) billow like a large sail into the ventricle during early diastole but then abruptly decelerate as they meet the limits of movement.[2,7] The abrupt deceleration causes a loud, medium- to high-frequency sound, which is then followed by the mid-diastolic rumbling murmur of mitral stenosis. The opening snap is best heard between the apex and left lower sternal border.

The clinician can mimic the sound of snap and murmur together by first setting up the cadence of S_1, S_2, and opening snap (RUP = S_1; bu = S_2; DUP = opening snap):

RU**P** bu **DUP** RU**P** bu **DUP** RU**P** bu **DUP**

and then adding the murmur:

RU**P** bu **DUP**RRRRRRRRU**P** bu **DUP**RRRRRRRRU**P** bu **DUP**

In some patients the opening snap is so loud it is easily heard at the second left intercostal space, where it then mimics a widely split S_2. However, careful attention to inspiration in these patients may reveal a *triple* sound (split S_2 and opening snap) at this location, confirming the last sound to be the opening snap.

The opening snap of mitral stenosis was first described by Bouillard in 1835.[2]

II. CLINICAL SIGNIFICANCE

According to traditional teachings, the opening snap is inaudible in patients with mitral stenosis whose valve leaflets have become so thickened and inflexible they cannot create sound.[7,14] There is an inverse correlation between the opening snap amplitude and degree of calcification of the mitral valve ($r = -0.675$, $p < 0.01$).[15]

The interval between the A_2 component of S_2 and the opening snap (A_2-OS interval) has been used to gauge the severity of mitral stenosis. Patients with more severe obstruction tend to have a narrower A_2-OS interval than those with milder disease. This occurs because the mitral valve opens when the pressure in the relaxing ventricle falls below the atrial pressure; the more severe the obstruction, the higher the atrial pressure and the sooner this crossover occurs. Nonetheless, determining the A_2-OS interval is primarily a phonocardiographic exercise, not

*Patients with tricuspid stenosis also may have an opening snap, but all of these patients also have mitral stenosis and the mitral opening snap. Differentiating tricuspid and mitral opening snaps by auscultation is difficult.

an auscultatory one.[16] Furthermore, the A_2-OS interval also depends on variables other than severity of stenosis, such as ventricular relaxation time and heart rate, which further complicates interpreting it accurately at the bedside.[16]

The opening snap does indicate that the accompanying diastolic murmur represents mitral stenosis and not a flow rumble from increased flow over a nonstenotic valve (see Chapter 46 for discussion of flow rumbles).

PERICARDIAL KNOCK

The pericardial knock is a loud early diastolic sound heard in 28% to 94% of patients with constrictive pericarditis (see Chapter 47). It is heard over a wide area between the apex and left lower sternal border. Compared with the third heart sound, the pericardial knock is a higher frequency sound (easily detected with the diaphragm of the stethoscope), appears over a wider area of the precordium, and occurs slightly earlier (although still later than the opening snap or widely split second heart sound).[17]

The pericardial knock results from the sudden deceleration of the filling ventricle as it meets the borders of the rigid pericardial sac.[17,18] In this way it is similar to the third heart sound, although the more abrupt deceleration of constriction is what probably makes the pericardial knock higher-pitched and louder than the third heart sound (see Chapter 41).

TUMOR PLOP

The tumor plop is an early diastolic sound representing prolapse of the pedunculated tumor from the atrium over the mitral (or tricuspid) valve into the ventricle. In two large series of patients with myxoma (283 patients), it was detected in 15% to 50% of patients.[19,20] Characteristically the intensity and timing of the tumor plop vary between examinations: the plop may occur as early as the timing of an opening snap or as late as that of the third heart sound. It is often associated with a diastolic murmur that mimics the rumbling murmur of mitral stenosis.[19]

PROSTHETIC HEART SOUNDS

I. INTRODUCTION

Abnormal prosthetic heart sounds may be the only clue explaining the patient's dyspnea, syncope, or chest pain. To recognize these abnormal sounds simply and quickly, the clinician must first understand the normal prosthetic heart sounds. This section focuses on rigid mechanical valves, such as caged-ball valves (Starr-Edwards),[†] single tilting-disc valves (Björk-Shiley, Medtronic-Hall), and bileaflet tilting-disc valves (St. Jude Medical).[21-23]

[†] The Starr-Edwards valve is no longer manufactured, but it is still in use.

II. PRINCIPLES

The important observations are (1) timing and intensity of opening and closing sounds, which typically have a clicking or metallic quality and are often audible without a stethoscope, and (2) associated murmurs. Any new or changing sound or murmur requires investigation.

A. OPENING AND CLOSING SOUNDS

In patients with caged-ball valves the opening sound is louder than the closing sound. In patients with tilting-disc valves (both single disc and bileaflet) the closing sounds are loud and the opening sounds are only faint or inaudible (Fig. 42.2).

1. CAGED-BALL VALVES

In the aortic position, the caged-ball valve produces a loud opening sound, which is an extra systolic sound occurring just after S_1 with timing identical to the aortic ejection sound (i.e., instead of just S_1 and S_2, *lub dup . . . lub dup*, the clinician hears *le**dup** dup . . . le**dup** dup*). Caged-ball valves in the mitral position produce an extra diastolic sound when they open, with timing identical to that of the opening snap (i.e., instead of S_1 and S_2, *lub bup . . . lub bup*, it is *lub bu**dup** . . . lub bu**dup***). These opening sounds should always be louder than the corresponding closing sound (i.e., closing sounds are coincident with S_2 in aortic prostheses and with S_1 in mitral prostheses). The finding of an inaudible or abnormally soft opening sound indicates something is interfering with excursion of the ball, such as thrombus.

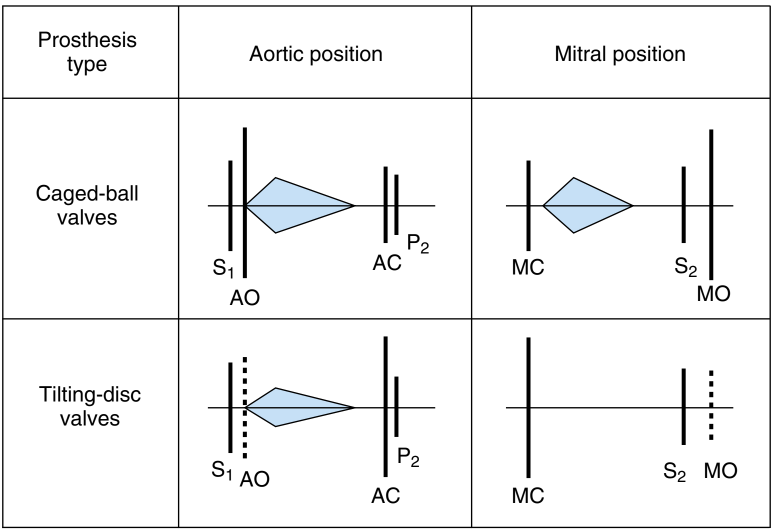

FIG. 42.2 PROSTHETIC VALVE SOUNDS. The normal findings of prosthetic valves, based on references 21-23. *AC*, Closure sound of aortic prosthesis; *AO*, opening sound of aortic prosthesis; *MC*, closure sound of mitral prosthesis; *MO*, opening sound of mitral prosthesis; P_2, pulmonary component of second heart sound; S_1, first heart sound; S_2, second heart sound. See the text.

2. TILTING-DISC VALVES

These valves produce distinct, metallic closing sounds coincident with S_1 (mitral position) or S_2 (aortic position). Patients whose closing sounds are abnormally quiet may have significant valve dysfunction.

B. MURMURS

In the aortic position, all rigid valves (caged-ball and tilting-disc) typically produce short midsystolic murmurs that are best heard at the base and sometimes radiate to the neck. Diastolic murmurs in these patients suggest perivalvular regurgitation and require investigation.[21-23]

In patients with rigid valves in the mitral position, any holosystolic murmur suggests perivalvular regurgitation and requires investigation. A normal finding in patients with the caged-ball valve in the mitral position (but not tilting-disc valves) is an early systolic to midsystolic murmur at the left sternal border. This murmur does not indicate regurgitation but instead represents turbulence caused by the cage of the valve projecting into the left ventricular outflow tract.[21-23]

The references for this chapter can be found on www.expertconsult.com.

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